LINEAR MOMENTUM TRANSFER AND LIGHT PARTICLE EMISSION IN THE ^{238}U (^{6}Li,ffx) REACTION

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Inclusive measurements of the linear momentum transfer distribution have been performed at E/A = 25, 30 and 35 MeV and exclusive studies of light charged particles as a function of linear momentum transfer have been performed at E/A = 25 MeV for the reaction of ^{6}Li ions with ^{238}U. Linear momentum transfer properties were derived from measurement of the folding angle between coincident fission fragments. Linear momentum transfer values and an upper limit for the complete fusion cross section, summarized in Table I, are nearly identical at the same E/A value to those for ^{12}C and ^{14}N ions[1] (Figure 1). Unlike the heavier ion data, the average linear momentum for ^{6}Li is about ten percent higher at each E/A value and the saturation in linear momentum transfer properties occurs at E/A = 30 MeV rather than E/A = 35 MeV.

TABLE I

Linear Momentum Transfer (LMT) and complete fusion properties for reactions of ^{6}Li with ^{238}U

	E/A (MeV) 25	30	35
Beam momentum (p_{beam})	1303 MeV/c	1423 MeV/c	1537 MeV/c
σ_{CF}/σ_R	0.22	0.20	0.16
Most probable LMT	1088 MeV/c	1157 MeV/c	1100 MeV/c
Most probable LMT/p_{beam}	0.85	0.81	0.72
Most probable LMT/A	188 MeV/c	193 MeV/c	183 MeV/c
Average LMT	967 MeV/c	986 MeV/c	956 MeV/c
Average LMT/p_{beam}	0.74	0.69	0.62
Average LMT/A	161 MeV/c	164 MeV/c	159 MeV/c

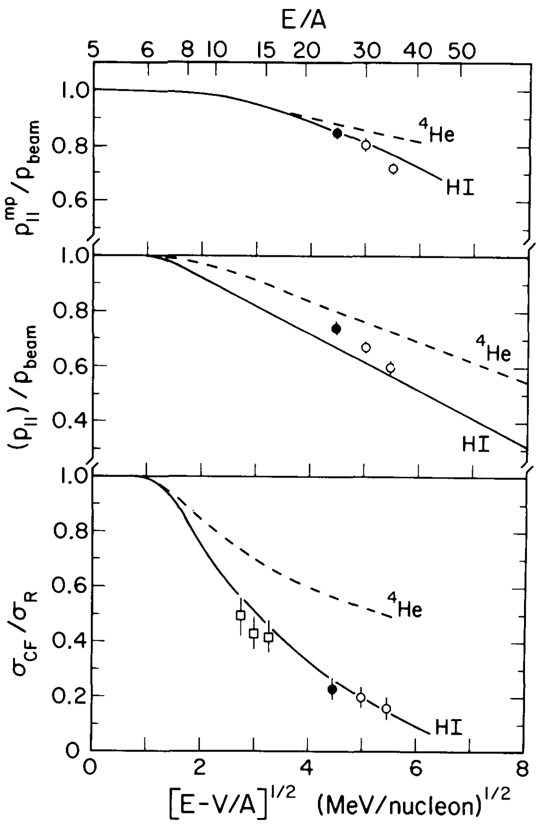

Figure 1. Plot of (a) most probable momentum transfer relative to the beam momentum, $p_{\parallel}^{mp}/p_{beam}$, (b) the average momentum transfer relative to the beam, $\langle p_{\parallel}\rangle/p_{beam}$, and (c) the upper limit for the ratio of the complete fusion cross section to the total reaction cross section, all plotted as a function of the beam velocity above the Coulomb barrier (lower scale) and E/A (upper scale). Solid circles are the present data, open circles are from Ref. 1 and open squares are averages for slightly lighter nuclei from Ref. 2. Solid lines summarize values for heavy-ions (^{12}C-^{40}Ar) and dashed line is for ^{4}He ions.

The exclusive light-charged-particle data demonstrate the existence of fission following the transfer of all possible components of the ^{6}Li projectile, including inelastic scattering. Absorptive breakup involving ^{4}He - ^{2}H cluster structure is found to be the dominant reaction mechanism. Linear momentum transfer (LMT) distribution for the fissioning nucleus relative to the beam momentum, $p_\parallel/p_{beam}$, are shown in Fig. 2. The distributions are divided into low- and high-energy bins, but show little sensitivity to this parameter. For the forward-angle measurements two components are apparent in the data; one corresponding to low LMT processes with $p_\parallel/p_{beam} \approx 0.2$ and the second to high LMT events with $p_\parallel/p_{beam} \approx 0.75$. In the former case one expects three projectile fragmentation channels to contribute to these yields: (^{6}Li, ^{6}LI$^* \to \alpha$ + p + n); (^{6}Li, ^{5}Li$^* \to \alpha$ + p) and (^{6}Li, ^{6}LI$^* \to \alpha$ + d$^* \to \alpha$ + p + n). These three processes are not distinguishable with our experimental method. Proton emission associated with high LMT values can be interpreted in terms of absorptive breakup involving capture of an alpha particle as the dominant mechanism, with some contribution due to complete fusion and A = 5 capture.

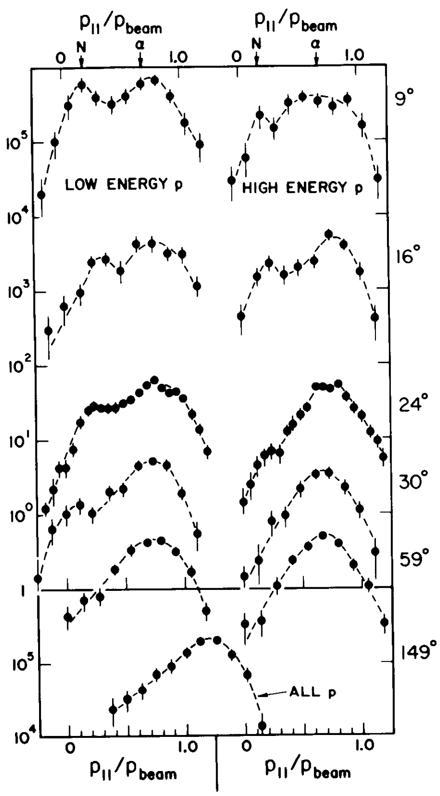

Figure 2. Fission fragment linear momentum transfer distributions gated on protons at several angles. For forward angles the proton energy spectra are divided into low- and high-energy bins, with the cross section divided approximately equally between the two. At 149 degrees all data are binned together. Expected centroids for transfer of a single nucleon and a ^{4}He ion (α) indicted by arrows.

At backward angles (Θ = 150°) we observe only protons with significant yields. These proton spectra are associated with complete momentum transfer (hence, $p_\parallel/p_{beam} \approx 1.2$ for the fissioning nucleus). In addition, the nuclear temperature inferred from the corresponding spectra is more than three times as large as that for a fully-equilibrated compound nucleus. Similar observations for ^{6}Li projectiles have been reported by Vigdor et al[2] at lower energies.

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1) M. Fatyga et al., Phys. Rev. Lett. 55, 1376 (1985).

2) S.E. Vigdor et al. Phys. Rev. C 26, 1035 (1982).